Marine Water Quality

Every time we visit the beach, fish, or dig clams in Puget Sound, we rely on good water quality. Marine water quality in much of Puget Sound is poorer than we would like, especially in areas where the circulation of water is restricted.

The marine waters of Puget Sound are affected by many different factors including weather and climate, inflow from rivers and streams, discharges from wastewater treatment plants and industries, off-shore ocean conditions, storm-water runoff, and even ground water.

Excess pollution can force beach closures and shellfish harvesting restrictions, and may cause algae blooms that eventually deplete oxygen levels leading to fish kills.

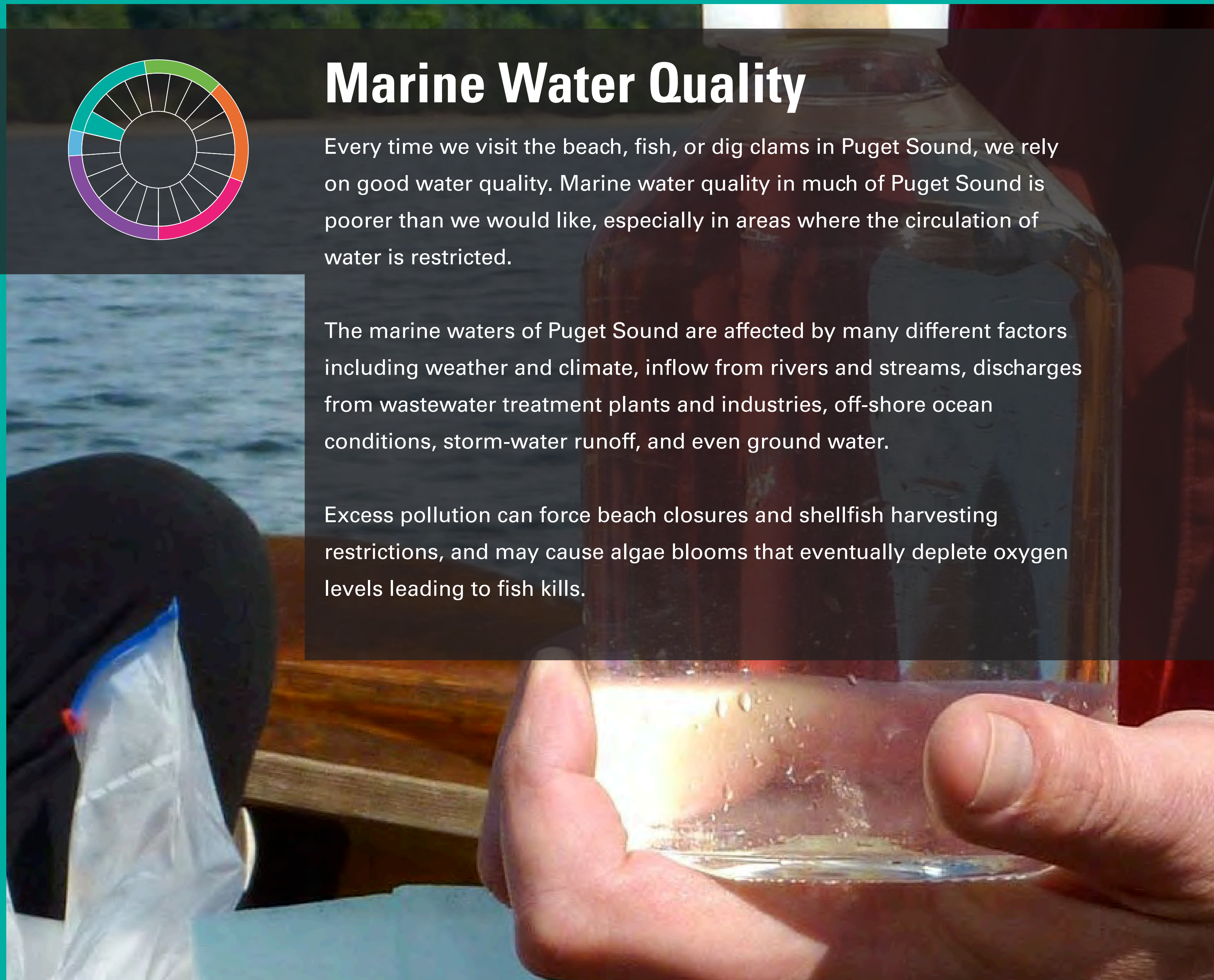


Photo Credit: Duane Fagergren, Puget Sound Partnership

Marine Water Quality

INDICATOR:

Marine Water Condition Index

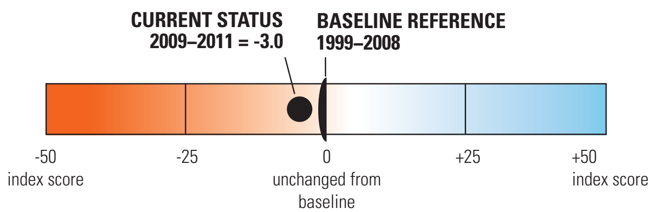
Indicator lead: Christopher Krembs, Washington Department of Ecology

TARGET:

The Leadership Council has not adopted a specific target for the Marine Water Condition Index. They did, however, adopt a target related to one key component of the index: Keep dissolved oxygen levels from declining more than 0.2 milligrams per liter in any part of Puget Sound as a result of human input.

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	NO



Using 1999–2008 as the baseline period with zero indicating conditions unchanged from the baseline, water quality conditions were slightly worse, on average, from 2009 to 2011.

Progress Towards 2020 Target

Marine Water Condition Index

Marine water quality was generally lower throughout Puget Sound in 2009 and 2010 relative to the ten year, 1999–2008 baseline. Conditions improved somewhat in 2011, with higher index scores reported in every one of the 12 regions monitored (Figure 1).

Dissolved Oxygen

For the most part, comprehensive studies to evaluate human contributions to low dissolved oxygen have not yet been completed in Puget Sound. A number of previous studies have suggested human inputs may be contributing to low dissolved oxygen problems. However, a recent study of Hood Canal indicated that human releases of nitrogen were unlikely to be contributing to low dissolved oxygen in the main arm of the Canal. The same study found that human inputs to Lynch Cove (in the southern part of Hood Canal) may be cause for concern, although the available data remains unclear.

Additional studies will be required to refine current models and improve our understanding of the degree to which human inputs contribute to low dissolved oxygen problems in Puget Sound, and what management actions may be necessary to address them.

What Are These Indicators?

Marine Water Condition Index

The Washington State Department of Ecology developed the Marine Water Condition Index (MWCI) to better address the large amount of variability inherent in marine water quality measures, in order to detect subtle changes over time.

The MWCI integrates 12 variables that describe an important aspect of water quality conditions (e.g. temperature, salinity, nutrients, algae biomass, dissolved oxygen, etc.). The goal of the MWCI is to provide a framework that links changes in local water quality and physical conditions to a larger context of oceanic water quality and natural variability. The MWCI can detect subtle changes in water conditions relevant to eutrophication and physical conditions against site and seasonal-specific baseline conditions measured from 1999 to 2008.

The index is reported on a scale of -50 to 50 indicating a complete change from baseline conditions, with zero indicating unchanged conditions relative to the baseline. The index is reported for 12 regions (Figure 1).

Dissolved Oxygen

Low dissolved oxygen has been observed in a number of locations in Puget Sound and can create significant problems, such as extensive fish kills, human inputs, especially nutrients, are often suspected of creating, or exacerbating, the conditions which lead to low oxygen in Puget Sound. To reduce the frequency and severity of oxygen problems in Puget Sound, the Leadership Council adopted a target intended to minimize any human contributions to low dissolved oxygen in Puget Sound.

The problem is, dissolved oxygen naturally exhibits a high degree of variability in marine waters, changing almost continuously with time of day, location, season, tidal cycle, depth, the mixing and movement of different water sources, and many other factors. Also, there are several main sources of nitrogen entering Puget Sound, including the ocean (generally the largest overall source), terrestrial sources (some of which are natural, and some of which are human), groundwater, and the atmosphere.

Consequently, determining the precise degree to which human inputs are responsible for a relatively small decline in dissolved oxygen, relative to the normal range of variability, is a complex issue. Addressing the issue requires a combination of good monitoring data, studies on the sources of nitrogen, and sophisticated mathematical models.

Marine Water Condition Index Scores
1999-2011

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Admiralty Reach	20	13	8	4	0	-5	-3	-5	4	0	-3	-2	14
Georgia Basin	-2	14	13	1	-2	10	-2	-7	1	9	-9	7	16
South Hood Canal	16	7	9	3	-4	-9	-1	-11	6	10	-1	-14	-11
Central Basin	15	14	12	8	0	-6	-8	-3	4	1	-7	-10	7
Bellingham Bay	10	13	23	-3	1	6	-12	-8	7	2	-12	-14	7
Sinclair Inlet	8	16	13	1	-1	-6	-5	-11	4	1	3	-13	3
Oakland Bay	16	13	14	-4	-6	-9	-5	1	4	-3	1	-6	1
South Sound	19	14	14	-2	4	0	-4	-2	3	0	-8	-12	9
Elliot Bay	28	19	5	-3	-9	3	-15	-9	3	4	-8	-5	5
Commencement Bay	17	8	13	-3	-6	0	-3	-1	7	-5	-8	-8	2
Whidbey Basin	11	8	8	-5	-2	-10	-1	1	9	7	-9	-14	-3
Budd Inlet	8	14	17	1	-12	-9	-7	-1	8	5	3	-8	1

Figure1. Marine Water Condition Index scores for twelve regions of Puget Sound, between 2001 and 2010. Changes in water quality relative to the 1999 to 2008 baseline are reported, with numbers greater than zero indicating improving water quality (in green), and numbers smaller than zero indicating decreasing water quality (in red).
Source: Washington Department of Ecology, Environmental Assessment Program, Marine Monitoring Unit

Marine Water Quality

Interpretation of Data

Status and trend

Marine Water Condition Index scores have generally declined over the past ten years, illustrated by a shift from green to red colors and an increase in negative scores (Figure 1). These results indicate that conditions overall are shifting in the direction of lower water quality, although recent, more stable conditions have slowed the apparent decline. The largest changes, more than 20% decline, were in South Sound, Bellingham Bay, and Central Sound.

The largest driver of declining marine water quality has been nitrate concentrations. Over the past ten years, nitrate levels have increased significantly. Because nitrate is an important plant nutrient, increasing nitrate loads can fuel algae blooms which, as the algae subsequently die and decay, can drive low dissolved oxygen events.

There are two dominant sources of nitrate in Puget Sound waters: input from ocean waters flowing into Puget Sound and human pollution. Recent evidence suggests that increasing nitrate loads to Puget Sound are predominately non-oceanic. However, as discussed earlier, the overall contribution of human inputs to low dissolved oxygen in Puget Sound remains a topic of active study.

Rain Gardens to the Rescue

Puyallup Gets Disconnected

Since 2009, the City of Puyallup has educated hundreds of citizens on stormwater pollution prevention through its Rain Garden Program. As a result, more than one million gallons of stormwater were disconnected from the city's stormwater system.

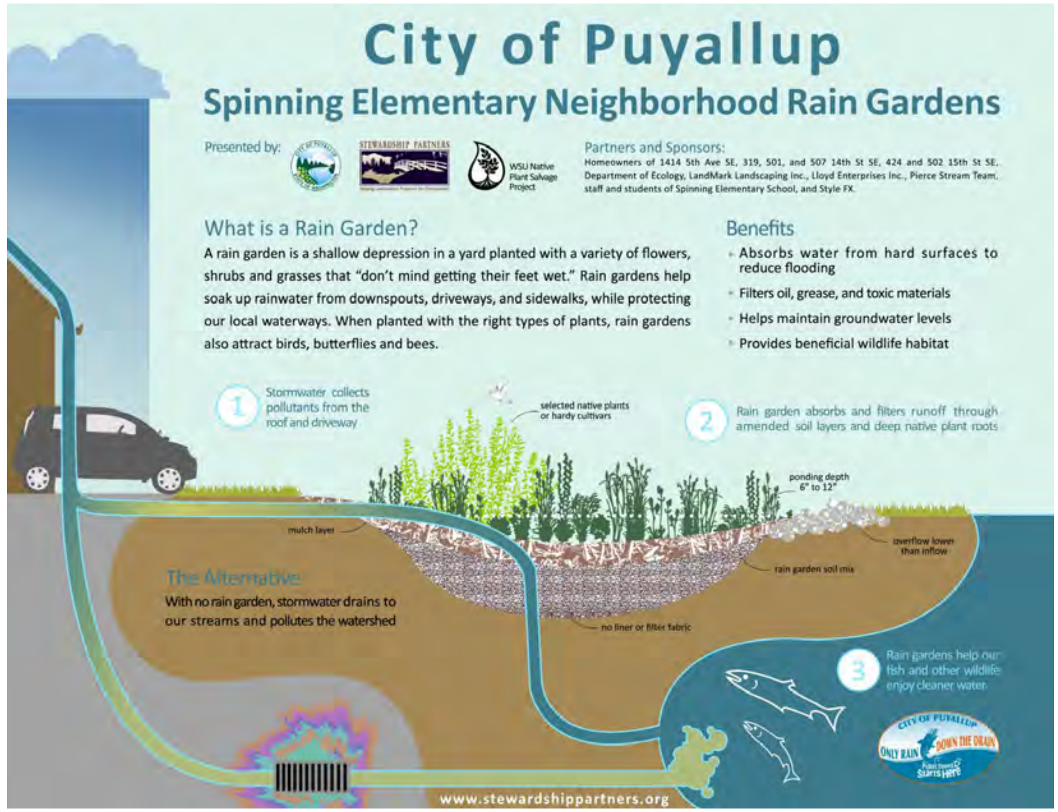
Although stormdrains are designed to collect and carry stormwater, they do not treat the water before it is channeled to Puget Sound through our streams, lakes, and rivers. Our streams and rivers were not intended by nature to carry these large volumes of stormwater. This runoff carries pollutants from our yards and roads into the waterways that are dumped untreated into Puget Sound.

Rain gardens are a beautiful way to manage stormwater runoff naturally where it originates, rather than letting it flow into the stormdrains. Planting native perennial flowers, shrubs, and grasses in a shallow flowerbed helps reduce flooding by capturing stormwater that runs off hard surfaces such as driveways and sidewalks. Rain gardens remove oil, grease, and other pollution by filtering water through layers of soil and plant roots before recharging groundwater supplies.

The city of Puyallup is creating demonstration sites to educate the public on stormwater issues and how each homeowner and business can work to minimize their impervious footprint in our watershed. Other ways to keep runoff out of the stormwater system include harvesting rainwater in a rainbarrel or cistern and installing porous pavement on your property. Rooftop gardens are also another option.

Since the program began, 62 rain gardens, including seven large rain garden clusters, have been installed in Puyallup. By coordinating with homeowners to install grant-funded rain gardens and other GSI at private homes, we are also helping our citizens to beautify their yards and neighborhoods and build community relationships.

Funding for Puyallup's Rain Garden Program came from Washington State's Department of Ecology grant programs as well as donations from several local businesses and individuals.



Freshwater Quality

The rivers and streams that flow into Puget Sound are the lifeblood of our region's ecosystems and our health, economy, and quality of life. Yet only 64% of the major rivers in Puget Sound meet water quality goals.

Clean water is vital to people and to healthy fish and wildlife populations. When our rivers and streams pick up pollutants, toxic contaminants, or excessive sediments and nutrients, it adversely affects the health of our watersheds, marine waters, swimming beaches, and shellfish beds.

Three key indicators help us monitor the health of Puget Sound: the number of impaired waters, the Water Quality Index (WQI), and the Benthic Index of Biotic Integrity (B-IBI). Under the federal Clean Water Act of 1972, waters that fail to meet water quality standards are considered impaired. The WQI integrates complex water quality data into a readily understood scale. The B-IBI measures the abundance and diversity of macroinvertebrates in a streambed. Also known as stream bugs, these creatures are a critical part of the aquatic food web and are sensitive to changes in the environment.

Photo Credit: Flickr @ pfly

Freshwater Quality

INDICATOR:

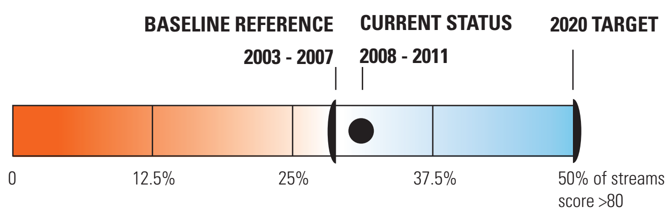
Water Quality Index

Indicator lead: David Hallock, Washington Department of Ecology

TARGET:
At least half of all monitored streams should score 80 or above on the Water Quality Index.

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	YES



During the 2003-2007 baseline period, 29% (16 of 55 stations) met the target value based on averaging index scores for each site during this period (Water Quality Index >80). During 2008-2011, 31% (17 of 55 stations) met the target value (a slight increase).

Progress Towards 2020 Target

There has been slight progress towards the 2020 target as monitored sites showed a very slight increase in the number of sites with Water Quality Index (WQI) scores of 80 or above. However, results from the trend analysis of 14 of the major rivers at their most downstream sites suggest that we are not likely to reach the target by 2020.

The earliest projection to meet the target for these 14 rivers would be 2025. When adjusted for differences in seasonal flows, the trend is much slower: average flow-adjusted scores of 80 are projected for 2060. Flow-adjusting accounts for the effect of flow on the parameters underlying the index.

However, this kind of estimate is a best guess due to fluctuations in drivers like the rate of population growth, global warming, and effectiveness of management activities, as well as possible long-term cycles not visible in the current 15-year dataset. For example, management tends to address the easier and more egregious problems first. As those problems get fixed, remaining problems become more difficult to correct with less effect on the water body for a given level of effort. Consequently, the rate of improvement in the index could be less, perhaps much less, than predicted by simply extending current trends.

What is This Indicator?

The WQI for rivers and streams combines eight measures of water quality. Expectations for four of the component measures (dissolved oxygen, pH, temperature, and fecal coliform bacteria) are tied to the State's Water Quality Standards for protecting aquatic life and contact recreation. The other four measures (nitrogen, phosphorus, suspended sediment, and turbidity) do not have numeric standards. Toxics are not included in the index.

Water Quality Index

Annual, 1994-2011

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Duckabush River nr Brinnon	94	92	96	78	92	89	93	95	94	90	74	94	89	85	88	96	86	89
Skokomish River nr Potlach	88	93	87	86	75	87	95	95	94	85	70	67	92	89	89	94	86	70
Snohomish River at Snohomish	83	77	82	76	89	83	92	91	89	81	74	75	89	75	81	85	79	77
Elwha River nr Port Angeles	83	83	79	80	87	74	86	88	83	76	73	74	89	67	66	81	81	76
Cedar River at Logan st/Renton	81	76	68	75	65	83	87	76	60	78	72	84	81	79	79	81	77	75
Skagit River at Marblemount	90	78	75	64	87	71	87	86	59	85	64	81	84	75	75	81	56	77
Skagit River nr Mount Vernon	75	73	72	65	84	77	89	91	71	76	61	73	77	77	75	76	74	73
Nisqually River at Nisqually	65	74	58	59	76	60	40	60	79	79	69	71	74	75	91	74	83	86
Deschutes River at East St Bridge		67	74	47	61	62	62	72	70	73	61	83	88	88	82	76	74	60
Stillaguamish River nr Silvana	83	70	66	58	71	70	81	60	44	72	55	67	71	69	75	75	71	59
Green River at Tukwila	62	52	35	50	63	70	82	73	66	67	75	49	72	68	60	69	63	68
Samish River nr Burlington		66	59	50	58	66	86	75	32	49	34	71	67	74	59	80	63	52
Nooksack River at Brennan	73	56	49	41	62	42	65	68	58	57	52	54	61	51	60	69	56	55
Puyallup River at Meridian St	49	52	47	48	41	62	60	58	57	55	51	58	59	58	61	49	62	56

Table 1. Annual WQI scores for monitoring stations near the mouth of 14 major rivers. Scores are calculated for each water year from October 1st to September 30th. Higher numbers indicate better water quality. Scores 80 or above are shown in green, 70 to 79 in orange, 40 to 69 in pink, and scores 39 or less are in red.

Index values are based on monthly monitoring at individual stations. The index values range from 1 to 100; a higher number is indicative of better water quality. However, a particular station may receive a good WQI score, and yet have water quality impaired by parameters not included in the index. Similarly, some locations may have poor WQI scores based on measures that do not have Water Quality Standards.

Interpretation of data

Status and trend

From 2008-2011, 17 of the 55 long-term monitoring stations reported average WQI scores of 80 or more, indicating that they support water quality goals for conventional pollutants (toxics are not included); 11 stations had values that were "borderline" (70 – 79); 25 had "poor" scores (40 – 69); and two stations had a very poor index score (< 40) (Figure 1). For major rivers, three out of 14 stations reported average WQI scores of 80 or higher during this time period (Table 1).

Freshwater Quality

WQI scores for major rivers in Puget Sound are in the mid 70s. These scores have slowly improved at a rate of about 0.4 units per year since 1995 (seasonal Kendall analysis, $p < 0.10$). Flow-adjusted scores have improved at a slower rate, 0.16 units per year ($p < 0.20$).

Scores have improved most strongly in the Nisqually and Deschutes systems (1.4 and 1.6 units per year, respectively, $p < 0.05$). No Puget Sound basins have had significantly declining scores ($p > 0.20$).

In addition to improvements in the overall scores for major rivers in Puget Sound, fecal coliform bacteria and total nitrogen index scores have improved. Other parameters are unchanged in freshwater systems as a whole, though there may be system-specific trends.

Stations meeting water quality goals are all in the relatively undeveloped Olympic Peninsula, except for the Snohomish River. Stations not meeting water quality goals tend to be in watersheds with more people and more agricultural development.

Freshwater Quality Index scores (averaged) for 55 sites in Puget Sound
2008-2011

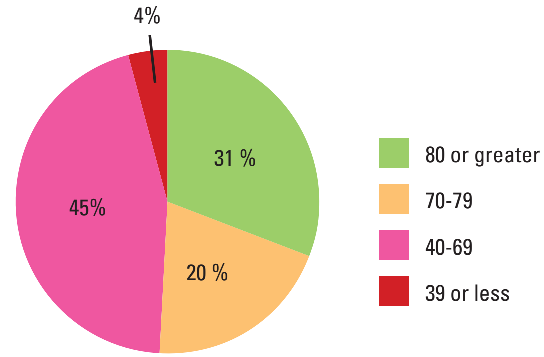


Figure 1. WQI scores (averaged) from 2008-2011. Shown are percentages of 55 sites by category for WQI. Higher numbers indicate better water quality.

Sources: *Statewide Water Quality Monitoring Network, Washington Department of Ecology; Stream and River Water Quality Monitoring, King*

INDICATOR:

Number of Impaired Waters

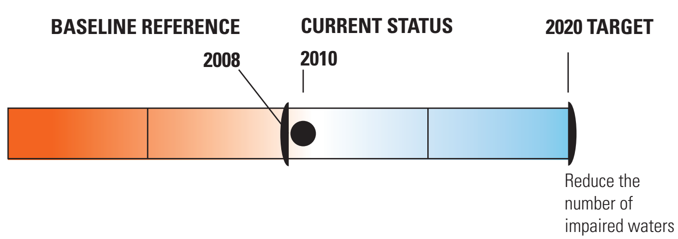
Indicator lead: Ken Koch, Washington Department of Ecology

TARGET:

Reduce the number of "impaired" waters

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	YES



From 2008–2010, the number of impairments decreased from 1573 to 1496 (a difference of 77). However, the next assessment (due in 2013) is expected to show a significant increase in impairments (a trend away from the 2020 target) due to an increase in data and the number of sites assessed.

Progress Towards the 2020 Target

Although the number of impairments for rivers and streams decreased by 77 segments in 2010 (Figure 1), it does not mean that these segments now meet water quality standards. Instead, the change in number of impairments was largely due to the number of segments receiving approval for their water quality improvement project plans or pollution control programs.

Having a plan in place removes a segment from the impairment list, but does not necessarily mean that the area has been restored or that water quality standards are being met. For example, only four segments from the 2010 list were removed from the impaired list because they met water quality standards.

New data for freshwater were not reviewed in 2010; the next water quality assessment for 2012 will use new data and be published in 2013. The number of freshwater impairments is likely to rise significantly in 2012 due to an increase in data and the number of sites assessed. Comparing the number of impairments for 2008 to 2012 will be difficult because the method used to map and count segments will change.

What is This Indicator?

Impaired waters are segments of streams, rivers, or lakes that do not meet Washington State's Water Quality Standards for bacteria, dissolved oxygen, temperature, toxics, or other pollutants. Cool, clean water is a key ingredient for a healthy Puget Sound. When lakes and streams have a reduced ability to support native species and human uses, then they are listed as Impaired.

Washington Department of Ecology reviews data from a variety of sources every four years to identify impairments. The data used to list segments as impaired must meet rigorous data quality standards as outlined in

Freshwater Quality

Washington's Water Quality Policy 1-11.

Under the Federal Clean Water Act of 1972, waters are considered impaired when they fail to meet water quality standards or minimum requirements for certain uses. Every two years, states are required to prepare a list of water bodies that do not meet water quality standards. This list is called the 303(d) list, because the process is described in Section 303(d) of the Clean Water Act. To achieve this goal, Washington State established water quality standards designed to protect and restore water quality for drinking, recreation, and habitat for fish and other aquatic life.

More than one segment of a river may be listed as impaired, and a single segment may be listed for more than one pollutant. Once a segment is listed as impaired, a plan must be created and implemented to control pollution or improve water quality. The effects of these restoration programs can take many years to have a positive impact.

Interpretation of Data

Status and trend

In the Puget Sound basin, the 2010 Water Quality Assessment showed a total of 6,957 segment and parameters combinations were assessed. A total of 1,496 river and stream segments, in 525 rivers and streams, did not meet Water Quality Standards and thus were listed as impaired.

Impairments occurred in all 19 Water Resource Inventory Areas (WRIAs) in the Puget Sound basin (Figures 2 to 4). More than 60% of the total number of listings for Puget Sound rivers and streams were in five watersheds: Nooksack (296 listings), Kitsap

Number of stream and river segments listed in each assessment category
2008 and 2010

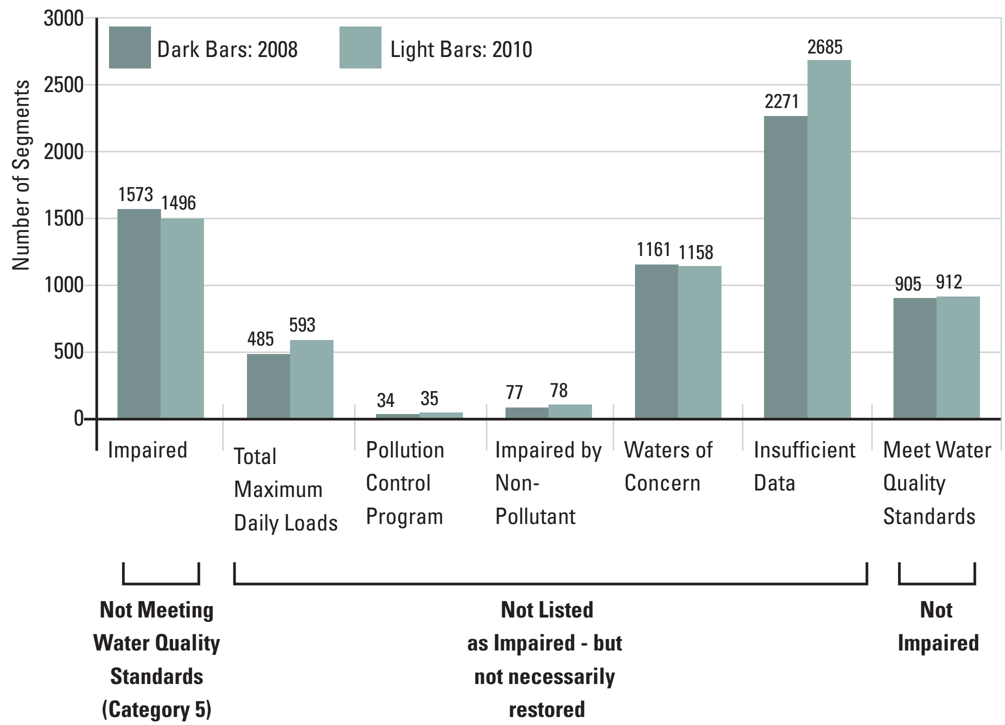


Figure 1. Number of stream and river segments listed in each assessment category for 2008 and 2010. Category assignments are from Washington Department of Ecology's Water Quality Assessment process for Puget Sound watersheds. The 2010 Assessment was focused on marine waters and, therefore, showed minimal changes to freshwater listings.
Source: *Washington States's Water Quality Assessment and 303(d) list.*

(194), Cedar/Sammamish (181), Duwamish-Green (132), and Lower Skagit-Samish (109). For Puget Sound lakes, 52 were listed as impaired; 48% were listed for bacteria and total phosphorus, and approximately one half were listed for toxic chemical contamination.

The most frequently cited data for listing segments as impaired were bacteria (524 listings), dissolved oxygen (460), temperature (353), and pH (97). However, the largest number of segments (39%) could not be categorized because of insufficient data. Water Quality Standards include strict rules about the number of samples required to determine whether a segment is impaired or meeting standards.

Segments listed as waters of concern have data that indicate a problem, but not enough data to make a determination of impairment.

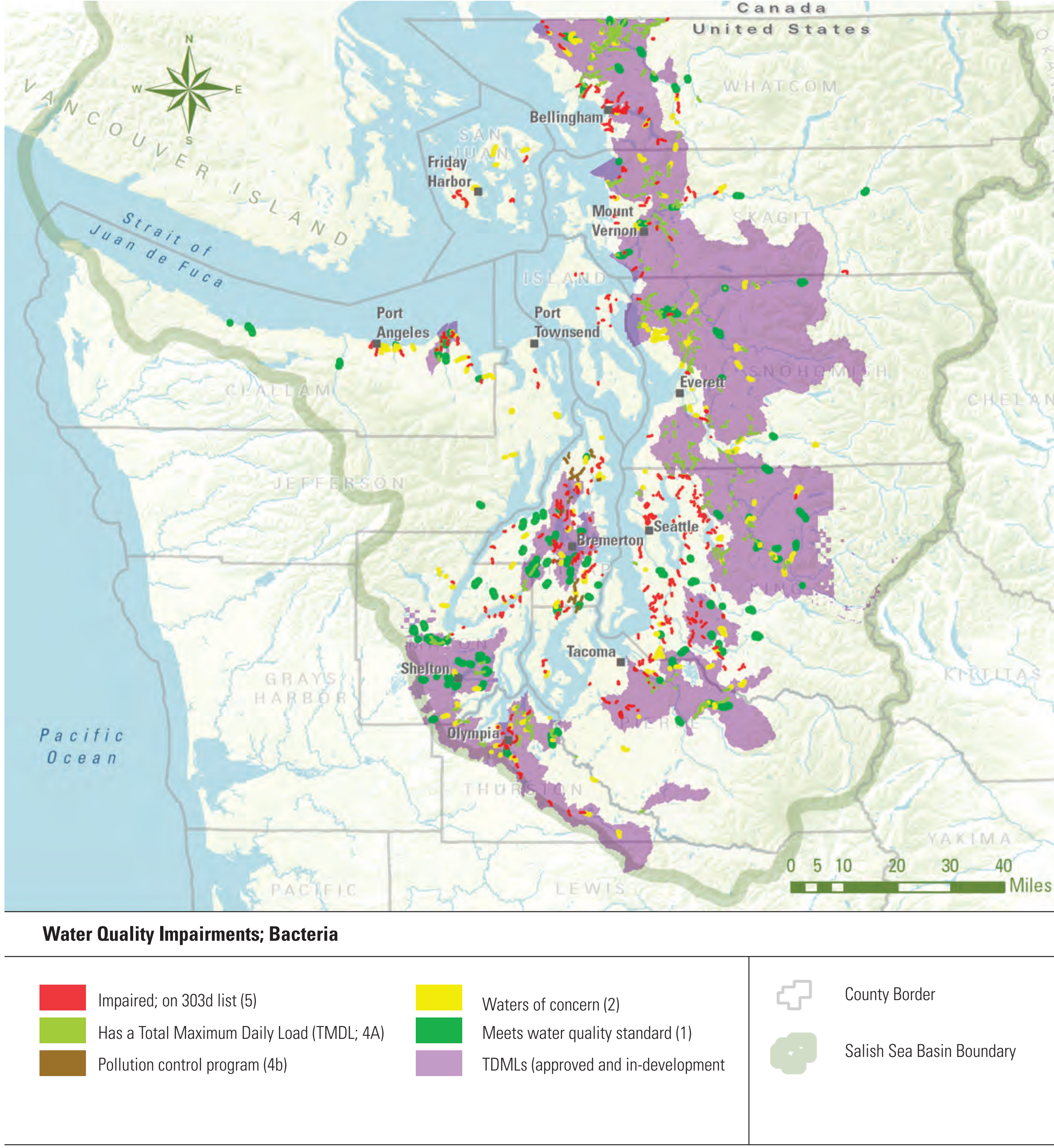


Figure 2. Rivers and stream segments listed as impaired for bacteria.
Source: Washington States's Water Quality Assessment and 303(d) list.

Sampling of streams, rivers, and lakes tends to focus in areas with known problems; therefore, not all segments have been assessed, and some impairments may be missed. Consequently, impairment data are not a complete reflection of the overall health of all streams, rivers, and lakes in Puget Sound watersheds.

In addition, selection of monitoring sites is frequently constrained by funding. Monitoring efforts are split between monitoring established sites and looking for new problems. This limits the numbers of new waters that are addressed during a cycle.

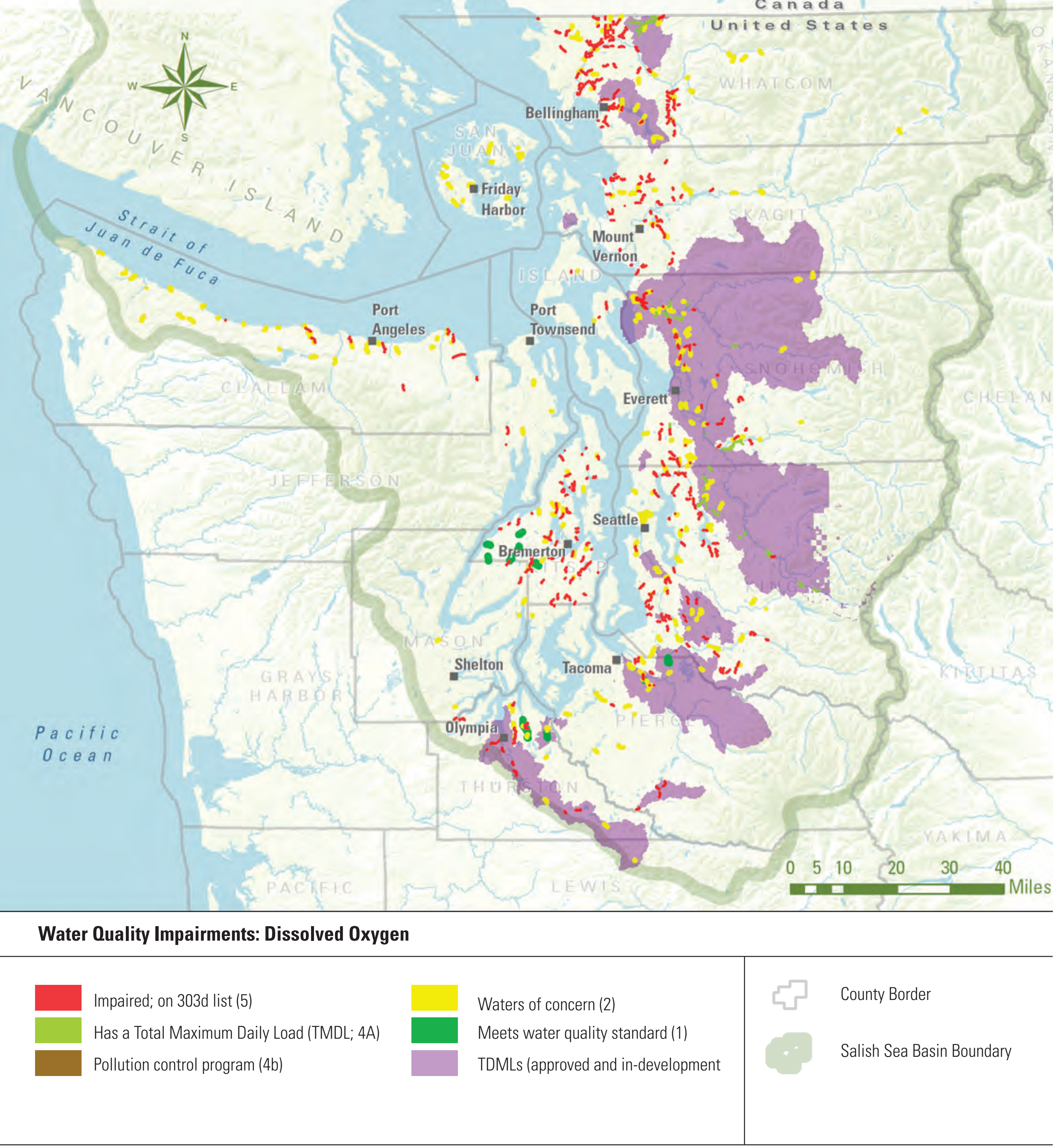
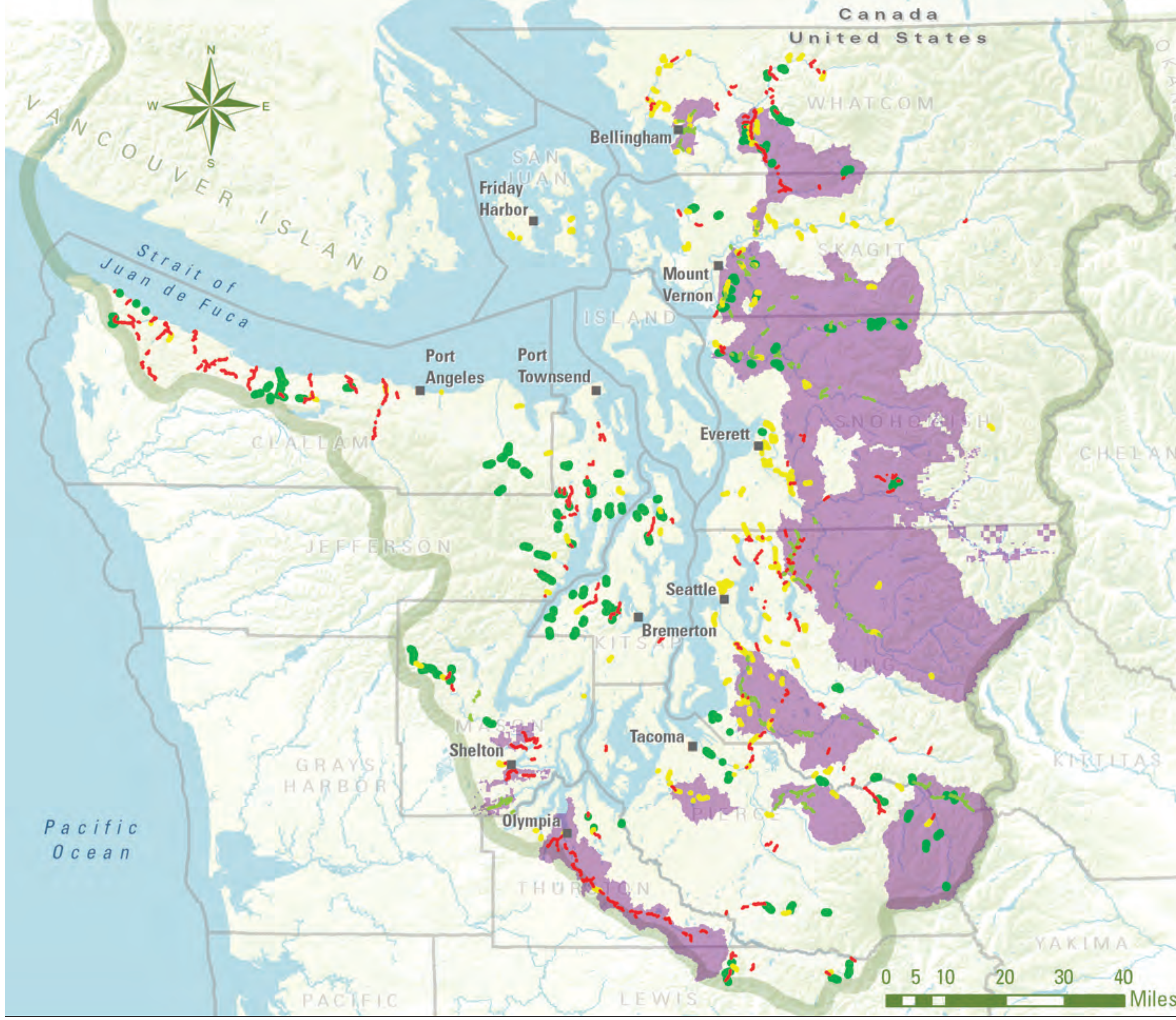


Figure 3. Rivers and stream segments listed as impaired for dissolved oxygen. *Source: Washington States's Water Quality Assessment and 303(d) list.*



Water Quality Impairments: Temperature

- Impaired; on 303d list (5)
- Has a Total Maximum Daily Load (TMDL; 4A)
- Pollution control program (4b)
- Waters of concern (2)
- Meets water quality standard (1)
- TDMLs (approved and in-development
- County Border
- Salish Sea Basin Boundary

Figure 4. Rivers and stream segments listed as impaired for temperature. *Source: Washington States's Water Quality Assessment and 303(d) list.*

Freshwater Quality

INDICATOR:

Benthic Index of Biotic Integrity (B-IBI)

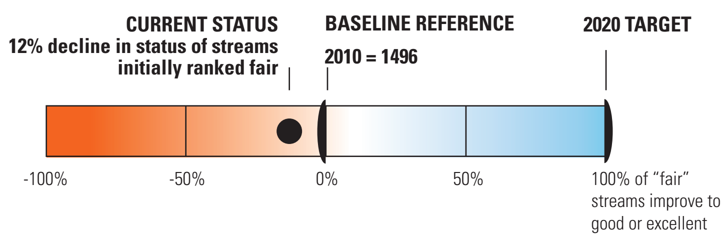
Indicator lead: Jo Wilhelm, King County

TARGET:

Protect small streams that are currently ranked “excellent” by B-IBI for biological condition; and improve and restore streams ranked “fair” so their average scores become “good.”

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	NO



For 128 sites with repeat visits during the last five years (2007 – 2011) more declined in condition to “poor” or “very poor” (26 sites) than improved to “good” or “excellent” (11 sites).

Progress Towards 2020 Target

No progress has been made. Overall, there was a net decline in condition of 12% of the 128 streams initially ranked “fair.”

From 2007-2011, a total of 245 stream sites were sampled more than once. Of these, a total of 91 sites had B-IBI scores indicating “fair” condition. Of these, 11 sites improved and changed categories to “good” or “excellent.” In contrast, a total of 26 stream sites declined and changed from “fair” to “poor” or “very poor.”

For the streams with “excellent” biological condition as rated by B-IBI, some streams are already protected. A detailed analysis has not been done to identify which streams and watersheds should be protected for this target. The watersheds will likely be small, five to 20 square miles.

What is This Indicator?

The indicator is the Benthic Index of Biotic Integrity (B-IBI). This index describes the biological condition of stream sites and their surrounding habitat based on the diversity and relative abundance of the benthic (bottom dwelling) macroinvertebrates living there, such as mayfly larvae, stonefly larvae, caddisfly larvae, worms, beetles, snails, dragonfly larvae, and many others.

Ten measures of biological condition are scored and summarized as the B-IBI, which ranges from a score of 10, indicating a very poor stream condition, to 50, indicating excellent condition.

B-IBI data are routinely collected and reported by more than 20 local jurisdictions, tribes, and other state and federal organizations in Puget Sound for a variety of reasons. In contrast, the Washington State Department of Ecology sampled 50 randomly-selected stream sites in 2009 and will sample again in 2013 to assess status and trend at the regional scale. Snohomish and King Counties also randomly select stream sites and report unbiased estimates of regional stream condition using B-IBI. For 84 sites with long-term data in King County, B-IBI scores for 68 sites did not change (81%), ten improved (12%), and six declined (7%).

Interpretation of Data

Status and trend

Biological condition ranged from very poor to excellent for streams assessed between 2007 and 2011. The majority of streams (88%) rated very poor, poor or fair, while fewer than 12% of streams were rated as good or excellent (Figure 1).

Not surprisingly, B-IBI scores were lower in areas with greater urban development (Figure 2). B-IBI is highly correlated with development and component metrics respond to specific aspects of disturbance. For example, long-lived species tend to decline as stream flows become higher in wet periods and lower in dry periods. Stoneflies also decline when natural vegetation near the stream is removed. Stream invertebrates are also sensitive to sediment, toxics, increased temperatures, and loss of habitat.

For sites with repeat visits during the last five years, more sites have declined in biological condition from “fair” to “poor” or “very poor” (29%) than have improved to “good” or “excellent” condition (9%; Figure 3). These B-IBI scores were not derived from a random sample design and, therefore, do not necessarily represent the entire Puget Sound area.

B-IBI scores by category of biological condition for Puget Sound streams
Annual, 2007-2011

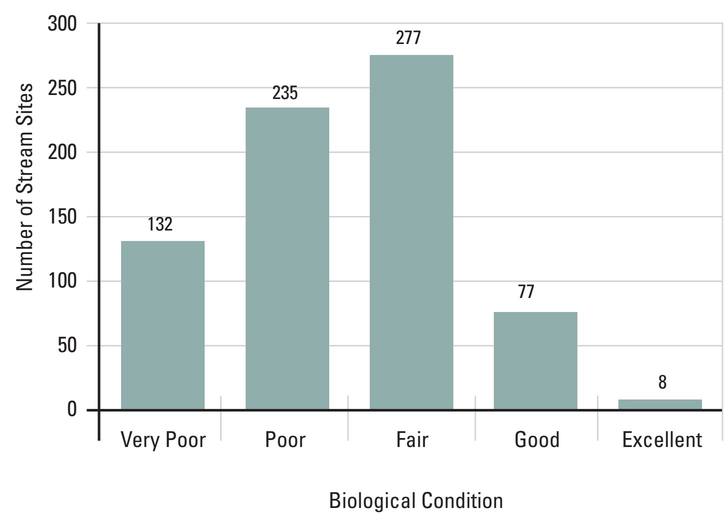


Figure 1. B-IBI scores by category of biological condition for Puget Sound streams. Shown are most recent data for each site.
Source: *Puget Sound Stream Benthos*

Freshwater Quality

B-IBI scores for 128 streams in Puget Sound
Annual, 2007-2011

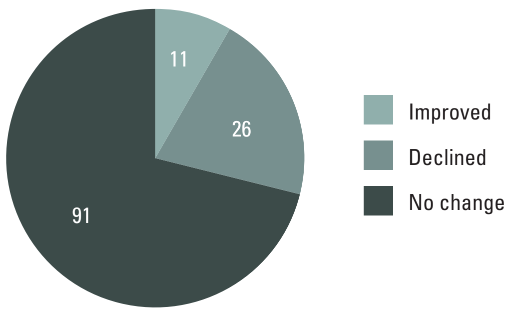


Figure 3. From 2007–2011, B-IBI was measured more than once at 245 sites. Of these, 128 stream sites were rated as "fair" by B-IBI for the first visit. Of these, 11 improved in condition to "good" or "excellent" condition; 26 declined in condition to "poor" or "very poor;" and 91 were still rated as "fair."
Sources: *Puget Sound Stream Benthos*

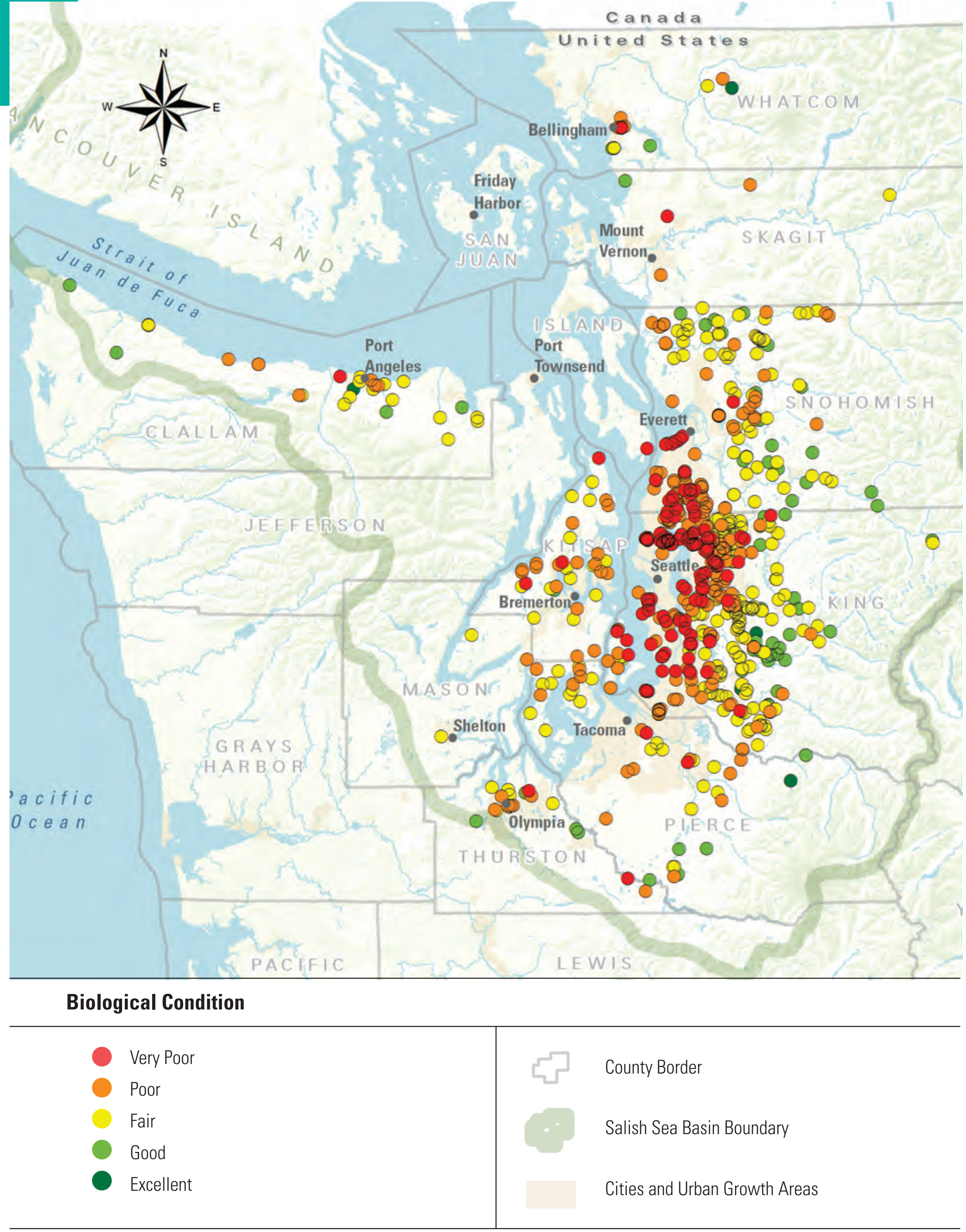


Figure 2. B-IBI scores for rivers and streams in the Puget Sound watershed
Source: Puget Sound Stream Benthos

Marine Sediment Quality

Much of the “floor” of Puget Sound is covered with sediment—the gravel, sand, silt, and clay that has accumulated over years, decades, centuries, and even millennia. The accumulation of sediment is a natural estuarine process that occurs as beaches and bluffs erode, as streams and rivers carve their way through watersheds and carry sediments from the land into the water, as glaciers grind down the rocks of mountains, and even as the teeming algae and microscopic animals die and settle slowly to the bottom.

These sediments form a unique habitat that is home to clams, marine worms, burrowing shrimp, bottom-dwelling fish, and thousands of other unique species that live in, or on, the bottom sediments. In turn, these animals form a critical part of the marine food web, help filter the overlying water, and even process and help breakdown the sediments themselves—much as earthworms and other soil organisms process and enrich the soils of our farms, gardens, and forests.

In a well-functioning estuary, marine sediments support a healthy biological community. But in Puget Sound sediments have become contaminated and adversely affect aquatic life that rely upon them.

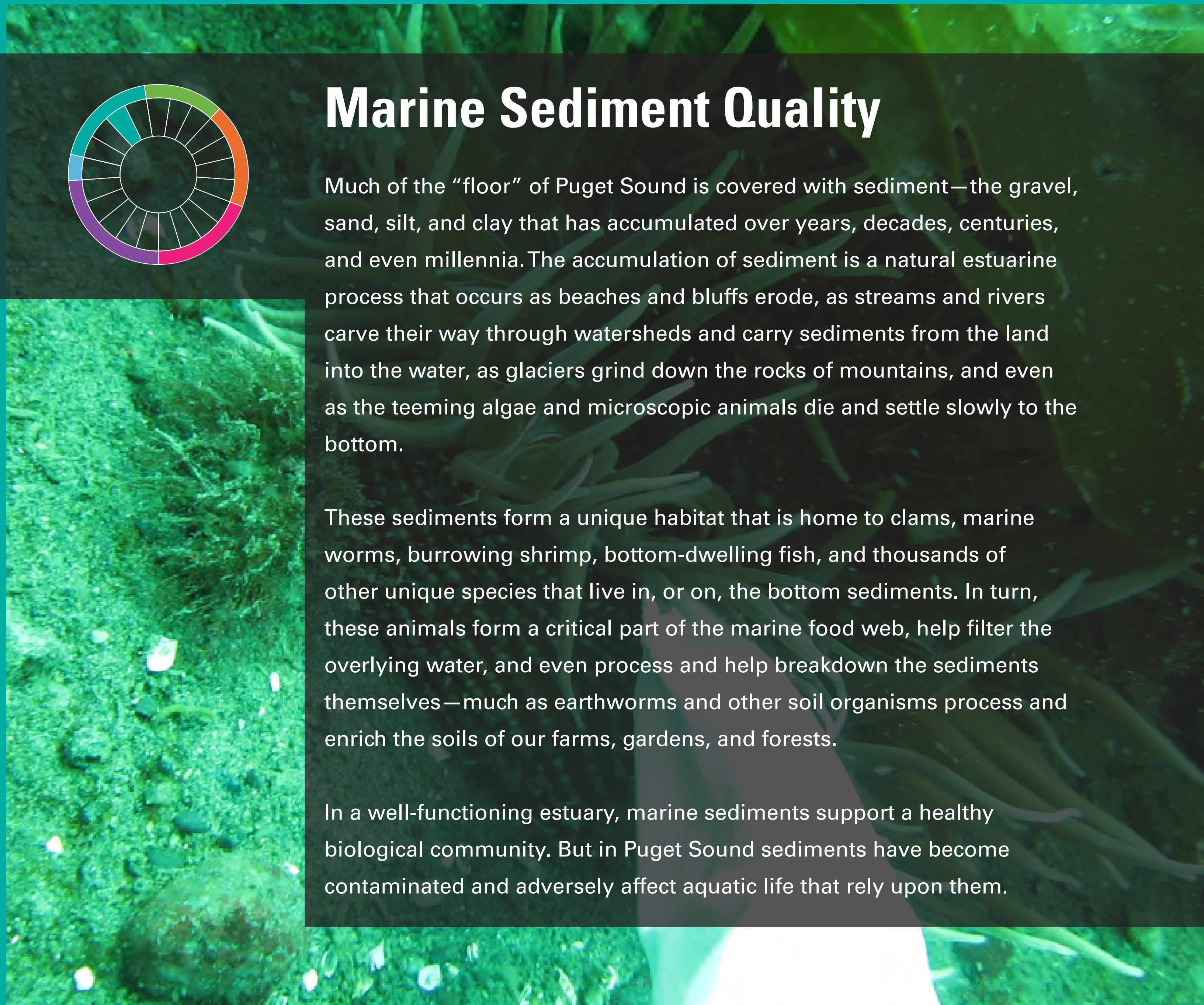


Photo Credit: Sean Sheldrake, EPA Region 10 diver

Marine Sediment Quality

INDICATOR:

Sediment Chemistry Index

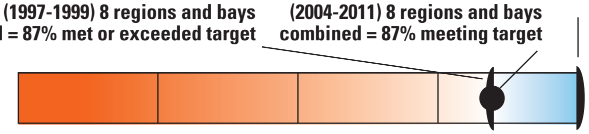
Indicator lead: Maggie Dutch, Department of Ecology

TARGET:

By 2020, all Puget Sound regions and bays achieve chemistry measures reflecting “minimum exposure” with Sediment Chemistry Index (SCI) scores >93.3.

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	NO



Five Puget Sound regions and three urban bays were sampled from 1997-1999, and re-sampled from 2004-2011. Results show no significant change between sampling periods, with seven of eight areas (87%) meeting (or not statistically different from) the target during both periods.

INDICATOR:

Sediment Quality Standards

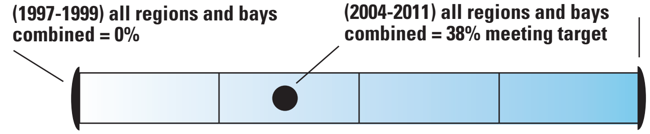
Indicator lead: Maggie Dutch, Department of Ecology

TARGET:

Have no sediment chemistry measurements exceeding the Sediment Quality Standards (SQS) set for Washington State

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	Yes



For five regions and three urban bays evaluated from 1997-1999, no area met the target that 0% of sediment chemistry measurements exceed Washington State Sediment Quality Standards. However, three of the eight areas re-sampled from 2004-2011 did meet this target.

Progress Towards 2020 Target

Sediment chemistry index values have met or exceeded the 2020 target in all areas sampled so far except Elliott Bay (Figure 1). In all areas that have been sampled twice, none showed any statistically significant change from their original results, including Elliott Bay. Even though the SCI score in Elliott Bay has improved, the change was not statistically different, hence our conclusion that we are not yet seeing progress in this target. Therefore, we remain slightly short of the 2020 goal that all regions and bays show an SCI score >93.3.

The number of individual chemicals exceeding state sediment quality standards (SQS) over the past decade is typically small (mostly less than 1%) except for Central Sound, Elliott Bay, and Commencement Bay, where the number still never exceeded 5%. Even fewer chemicals exceeded state SQS in the most recent round of sampling, with three areas dropping to zero and now meeting the target in those areas. Although the target is not fully met across all of Puget Sound, recent improvements suggest progress toward the target.

What are These Indicators?

The Sediment Chemistry Index (SCI) is one component of the Sediment Quality Triad Index. It combines data on the concentrations of a variety of chemicals into an overall index of chemical exposure (Table 1). Contaminants measured as part of the SCI include metals, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDEs – flame retardants), chlorinated pesticides, phthalates, some solvents, and various other pollutants. Note that analyses for newer chemicals of concern, such as dioxins, furans, endocrine disrupting chemicals, pharmaceuticals, personal care products, and perfluorinated chemicals, are not conducted as part of the PSEMP sediment component, and therefore not included in these Sediment Quality Dashboard Indicators.

Sediment Chemistry Category	Sediment Chemistry Index
Minimum Exposure	>93.0-100.0
Low Exposure	>80.0 - 93.0
Moderate Exposure	>66.0 - 80.0
Maximum Exposure	>0- 66.0

Table 1. Categories of exposure to chemicals and associated index values

Higher index values indicate less exposure to chemicals and thus healthier sediments (Table 1). Tracking the SCI gives an indication of how concentrations of those chemicals in marine sediments change over time, primarily in response to anthropogenic input, such as stormwater runoff and direct discharge, as well as cleanup activities and passive burial as cleaner sediments settle over older, and sometimes more contaminated, sediments.

The second (related) indicator reports the percent of individual chemical measurements that exceed the Washington Sediment Quality Standards (SQS). SQS values have been determined for a total of 47 chemicals in Puget Sound. Of those, 39 are included in the SCI and evaluated for this indicator.

Interpretation of Data

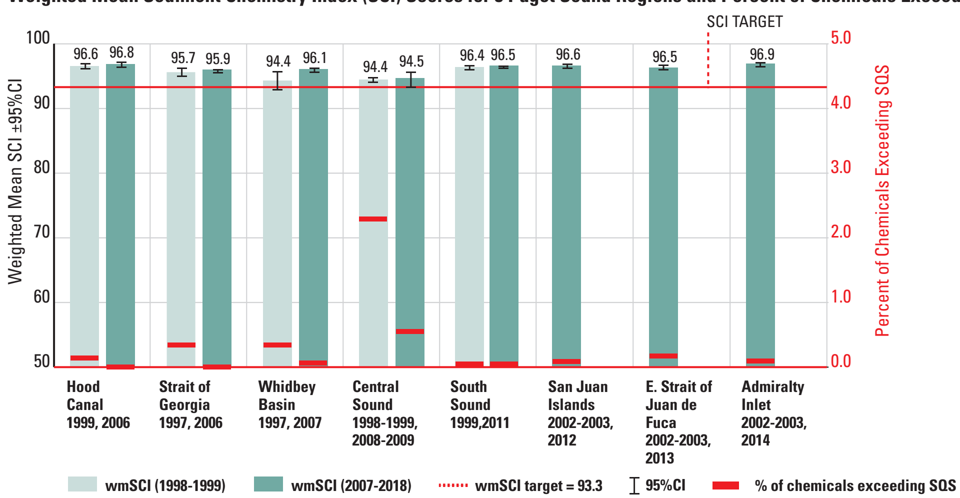
Overall, sediments in Puget Sound appear to be in generally good condition with regard to the measured suite of chemicals. Since 1997, all of the eight sampled regions and four of five urban bays met the SCI target, and values in most areas have changed little since the late 1990s.

In general, levels of toxic chemicals have been, and continue to be, highest in urban bays, but only Elliott Bay was clearly not meeting the SCI target in the low exposure category. The target has not been met in Elliott Bay since SCI scores were first calculated for data collected there in 1998, and only barely met in Commencement Bay, although scores in both bays appear to have improved over the years.

Given that sediment contamination generally changes very slowly, we expect most areas currently meeting the target to continue to do so through 2020 unless contaminant inputs to the areas increase. It is possible that the target may eventually be reached in Elliott Bay if conditions there continue to improve.

The second target, chemicals exceeding state sediment quality standards, was not met over the past decade in most regions and bays, again with urban bays—particularly Commencement and Elliott bays—showing the highest numbers. But the percent of chemicals exceeding the SQS value has

Weighted Mean Sediment Chemistry Index (SCI) Scores for 8 Puget Sound Regions and Percent of Chemicals Exceeding Sediment Quality Standards (SQS)



declined in most areas that have been re-sampled, with three regions—Hood Canal, Strait of Georgia, and South Puget Sound—now showing no sediment chemical values exceeding SQS, and both Commencement and Elliott bays dropping to below 3%. The value for Bainbridge Basin remained the same, below 1% for 1998 and 2009. Given the direction of the data, it is possible that values will continue to improve and may reach, or come very close to, the target by 2020.

Weighted Mean Sediment Chemistry Index (SCI) Scores for 6 Puget Sound Urban Bays and Percent of Chemicals Exceeding Sediment Quality Standards (SQS)

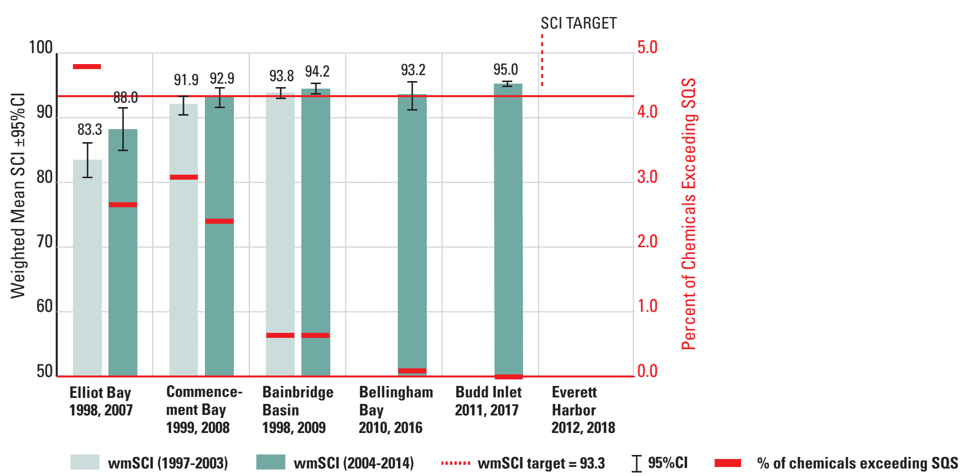


Figure1. The Sediment Chemistry Index (SCI) is shown for eight regions (left panel) and six urban bays (right panel). Light bars show results for first-round sampling efforts. Dark bars show results for second-round re-sampling. Higher values indicate healthier sediments. Also shown (red bars) are the percent of chemicals exceeding Sediment Quality Standards (SQS) for each sampling event.

Source: *Washington Department of Ecology, Marine Sediment Monitoring Team*

Marine Sediment Quality

INDICATOR:

Sediment Quality Triad Index

Indicator lead: Maggie Dutch, Department of Ecology

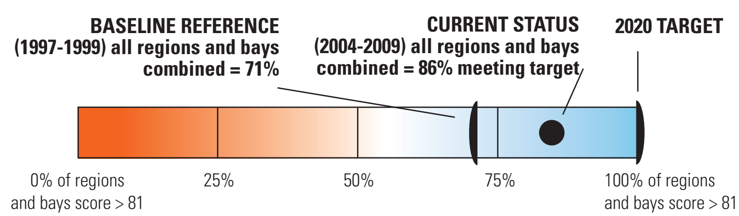
TARGET:

All Puget Sound regions and bays, as characterized by ambient monitoring, achieve the following: Sediment Quality Triad Index (SQTI) scores reflect "unimpacted" conditions (i.e., SQTI values >81)

The threshold criteria for "unimpacted" sediments has been revised from 83 (when the Leadership council adopted the target in 2011) to 81, based on quality control checks indicating the original calculation was incorrect.

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	Yes*



Four Puget Sound regions and three urban bays were first sampled in 1997-1999 and then re-sampled from 2004-2009. The most recent results showed an increase in the number of regions and bays meeting the target.

*Caution must be used in this interpretation as the weighted mean SQTI values suggest a decline in six of the seven re-sampled areas (see text).

Progress Towards 2020 Target

Sediment Quality Triad Index results suggest that much of Puget Sound has relatively healthy sediments. In the initial round of baseline sampling conducted between 1997 and 2003, four of eight regional areas and all three urban bays (64% of all areas combined) exceeded or were statistically no different from the target value of 81, indicating "unimpacted" sediments (Table 1, Figure 1). The remaining four regions (36% of all areas combined) had somewhat lower scores, but still fell within the range normally characterized as "likely unimpacted" (SQTI >57-81).

While the SQTI scores for the regions and bays fell in the two highest quality categories, values measured in resampled regions and bays still raise a concern. Among four regions and three bays that were re-sampled from 2004-2009, SQTI scores improved in only one area—Whidbey Basin—and declined in the other six areas (Figure 1). The improved score for Whidbey Basin increased the number of regions and bays meeting, or not statistically different from, the 2020 target (now six of seven areas = 86%), despite declining scores at all six other sampled locations . While the results indicate progress towards the target, there is also a somewhat concerning pattern of declining condition evident in sediments across the majority of regions and bays.

What is This Indicator?

Sediment quality is a key indicator of a healthy ecosystem, and high quality sediments support a diverse and important biological community. We monitor sediment quality in Puget Sound by measuring the levels of chemical contamination, assessing the toxicity of the sediments to marine life, and examining the diversity and health of the biological community.

Classification of sediment quality based on SQTI scores

Category	SQTI score	Interpretation
Unimpacted	>81-100	Confident that contamination and/or other stressors are not causing significantly adverse impacts to aquatic life in the sediment.
Likely Unimpacted	>57-81	Contamination and/or other stressors are not expected to cause adverse impacts to aquatic life in the sediment, but some disagreement among lines of evidence reduces certainty that the site is unimpacted.
Possibly Impacted	>36-57	Contamination and/or other stressors may be causing adverse impacts to aquatic life in the sediment, but the level of impact is either small or is uncertain because of disagreement among lines of evidence.
Likely Impacted	>5-36	Evidence of contaminant and/or other stressor-related impacts to aquatic life in the sediment is persuasive, in spite of some disagreement among lines of evidence.
Clearly Impacted	0-5	Sediment contamination and/or other stressors are causing clear and severe adverse impacts to aquatic life in the sediment.
Inconclusive	No SQTI score	Disagreement among or within lines of evidence suggests that either the data are suspect or additional information is needed for classification.

Table 1. Classification of sediment quality based on SQTI scores
Source: Washington Department of Ecology, Marine Sediment Monitoring Team

Citations Dutch, M.E., E.R. Long, S. Weakland, V. Partridge, and K. Welch. 2012. Sediment Quality Indicators for Puget Sound. Indicator definitions, derivations, and graphic displays. Washington State Department of Ecology. Unpublished document. 8 pp.

Long, E.R., S. Aasen, M. Dutch, K. Welch, and V. Partridge and D. Shull. 2007. Relationships between the Composition of the Benthos and Sediment and Water Quality Parameters in Hood Canal, WA: Task IV – Hood Canal Dissolved Oxygen Program. Washington State Department of Ecology Publication No. 07-03-40, Olympia, WA and Western Washington University, Bellingham, Wa. 197 pp. + appendices

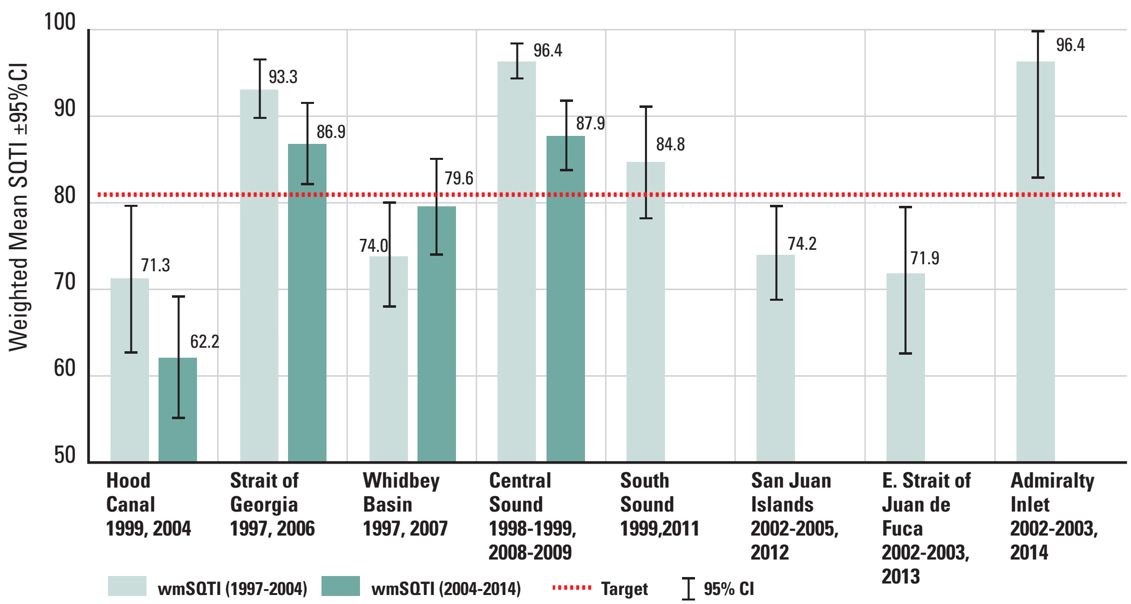
Marine Sediment Quality

In Puget Sound and many estuaries around the world, sediments have become contaminated with toxic chemicals from industrial discharges, contaminated run-off from urban streets and roads, discharges from wastewater treatment plants, agricultural and forest chemicals carried down rivers and streams, oil spills, and even chemicals carried long distances through the atmosphere that eventually fall out of the sky with our rain. As the forests around Puget Sound have been logged, our streams and rivers channelized, and towns and cities built up, the amount, rate, and quality of sediment deposited into Puget Sound has changed dramatically.

The Sediment Quality Triad Index (SQTI) provides a weight-of-evidence approach that combines three different types of data into a single index measured from 1 – 100, with higher index values indicating higher quality sediments (Table 1).

The SQTI combines the Sediment Chemistry Index (SCI), sediment toxicity data, and benthic invertebrate community (small animals in sediment) data into a single, broad measure of sediment quality[1]. The SCI measures the concentrations of chemical contaminants. Laboratory toxicity tests measure the combined (synergistic) effects of those chemicals and other sediment characteristics on laboratory test animals. And the benthic invertebrate data reflects the actual biological condition of the sediments as a response to all possible human-caused and natural stressors, whether measured or not.

Weighted Mean Sediment Quality Triad Index Scores in eight Puget Sound Regions



[1]Dutch, et al., 2012

Together, the SCI and SQTI Indicators describe the overall "health" of the sediments, including their ability to sustain the sediment-dwelling invertebrates that form an important component of the Puget Sound food web.

Sampling Design

The Washington Department of Ecology monitors sediments in eight regional areas across Puget Sound and, separately, in six urban bays (see map). Multiple replicate samples are collected during each sampling effort, and weighted according to the size of the area each sample represents. Because sediment condition is not generally expected to change quickly over time, regions and urban bays are sampled on a rotating basis over a ten- and six-year period, respectively, thus it takes ten years to complete one full round of regional sampling, and six years to complete one full round of urban bay sampling in Puget Sound.

In order to evaluate progress toward the targets, results are discussed here primarily for areas that have been sampled twice: generally first sampled in the late 1990s, and then re-sampled in the mid to late 2000s. Results are evaluated separately for regions (Figure 1, left panel) and urban bays (Figure 1, right panel). This allows comparison of sediment quality in areas more closely associated with urban and industrial discharges and runoff to areas with less intensively developed landscapes, keeping in mind that some

Weighted Mean Sediment Quality Triad Index Scores in six Puget Sound Urban Bays

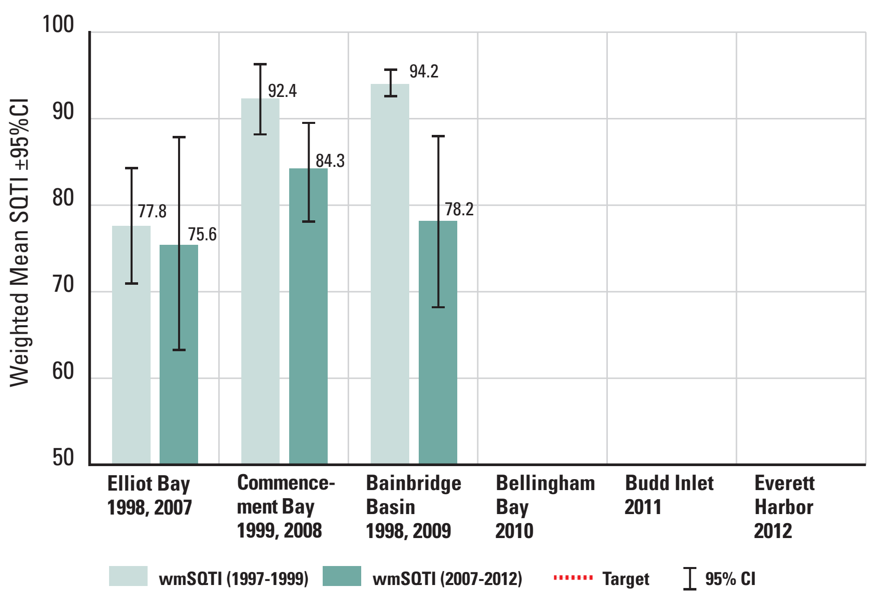


Figure1. Sediment Quality Triad Index, reported for eight regions (left panel) and six urban bays in Puget Sound (right panel). The light bars show the overall SQTI scores for samples collected in 1997-2003. The dark bars show the overall SQTI scores for samples collected in 2007-2009. The higher the index value, the higher the sediment quality. *Source: Washington Department of Ecology, Marine Sediment Monitoring Team*

Marine Sediment Quality

pesticides and certain other contaminants and natural impacts may in fact be more closely associated with agriculture and rural land uses.

Finally, it is important to note that results presented here are representative of only those regions and urban bays that have been sampled, and not necessarily all of Puget Sound since we do not have data for areas not sampled.

Interpretation of Data

Sediment quality monitoring in Puget Sound shows that about two-thirds of the areas monitored have sediments classified as "unimpacted", as indicated by low chemical concentrations, absence of toxicity, and the presence of abundant and diverse benthic invertebrate communities. The remaining one-third of the monitoring areas generally have sediments of "likely unimpacted" quality (Figure 1, Table 1).

Only a small percentage (~3.2%) of the sediment monitoring area in Puget Sound has sediments classified as "possibly, likely, or clearly impacted" (Table 1) with impairment in one, two, or all three components of the SQTI.[1] These impacted sediments are located in and around both the urban and industrial bays with measurable levels of chemical contaminants in the sediments, and in more rural bays which are likely experiencing pressure from other stressors, such as low dissolved oxygen in bottom waters. Although small in total area, the proximity of these impaired sediments to important river mouths and nearshore habitats may disproportionately affect fish, shellfish, and other aquatic life.

Trends

Despite the small improvement shown in this indicator relative to the target, the most striking feature of the data is the apparent widespread decline in overall SQTI scores. This decline was statistically significant in two areas: Central Sound and Bainbridge Basin.

The lower SQTI values were driven primarily by reductions in the benthic invertebrate community measures. There appear to be large increases in the incidence and spatial extent of adversely affected benthos between the first (baseline) samples collected in the late 1990s and more recent samples. Invertebrate abundance and species richness has decreased significantly in some areas. The reasons for the decline in benthic health are not known. Decline in benthic invertebrate communities is evident in both urban and

[1] unpublished data, Washington State Dept of Ecology; data not displayed.
[2] Long et al., 2007

Marine sediment monitoring regions and urban bays

- Admiralty Inlet
- Central Sound
- E Strait of Juan de Fuca
- Hood Canal
- San Juan Archipelago
- Strait of Georgia
- South Sound
- Whidbey Basin
- Cities and urban growth areas
- County border
- Salish Sea Basin boundary

Marine Sediment Quality

nonurban areas, with only limited correlation with changes in sediment chemistry or toxicity.

Since changes in the benthos aren't closely correlated to the chemical and toxicity-related environmental parameters currently being measured, other factors must be important. Benthic invertebrate communities are affected by a complex interplay of natural and human-caused variables, and there are many environmental factors that can impact benthic invertebrate populations that aren't measured by the SQTI. These include low dissolved oxygen, pH, sediment flux and loading, natural population cycles, and a variety of species interactions. All of these factors can have important local effects. For example, benthic communities sampled in Hood Canal in 2004 appeared to be adversely affected by very low, near-bottom dissolved oxygen concentrations.[2]

Other possible factors include the introduction of new chemicals of concern not currently monitored, and sub-lethal toxic effects such as reproductive impairment, that are not easily identified by current toxicity testing methods.

Over time, changes in sediment quality reflect the cumulative effects of many factors impacting the chemistry, physical processes, and biological responses of the Puget Sound ecosystem. The Sediment Quality Triad is a useful integrating measure of sediment condition, which can both explain observed effects, and help focus new inquiries on emerging problems.

Clean Sewers, Clean Thea Foss Waterway

LOCAL STORY

Located in the heart of downtown Tacoma, the Thea Foss Waterway was once characterized by dilapidated buildings, oil sheens, coal tar deposits, and contaminated bottom sediments which led the Environmental Protection Agency to declare the waterway a Superfund site in 1983. For more than 100 years, the Thea Foss Waterway had been a sink for waste from industrial dischargers and runoff from the upland drainages.

Today, it's a very different picture. The Thea Foss Waterway is the centerpiece of bustling marinas, internationally renowned museums, restaurants, grass esplanades, luxury apartments, and a variety of business and industry.

Even before the City of Tacoma and its partners finished the $105 million remediation of the Thea Foss Waterway in 2006, they knew it was imperative to find ways to protect the quality of the sediment and receiving water in the waterway.

While significant efforts were made by the City to reduce or eliminate ongoing sources of contamination to the storm drainage system, it was found that elevated levels of PAHs, PCBs , and mercury remained in sediment and debris collected from Tacoma's 100-year-old storm sewer lines. This legacy pollution was being washed into the Thea Foss by stormwater, threatening to degrade the quality of the newly remediated marine sediment.

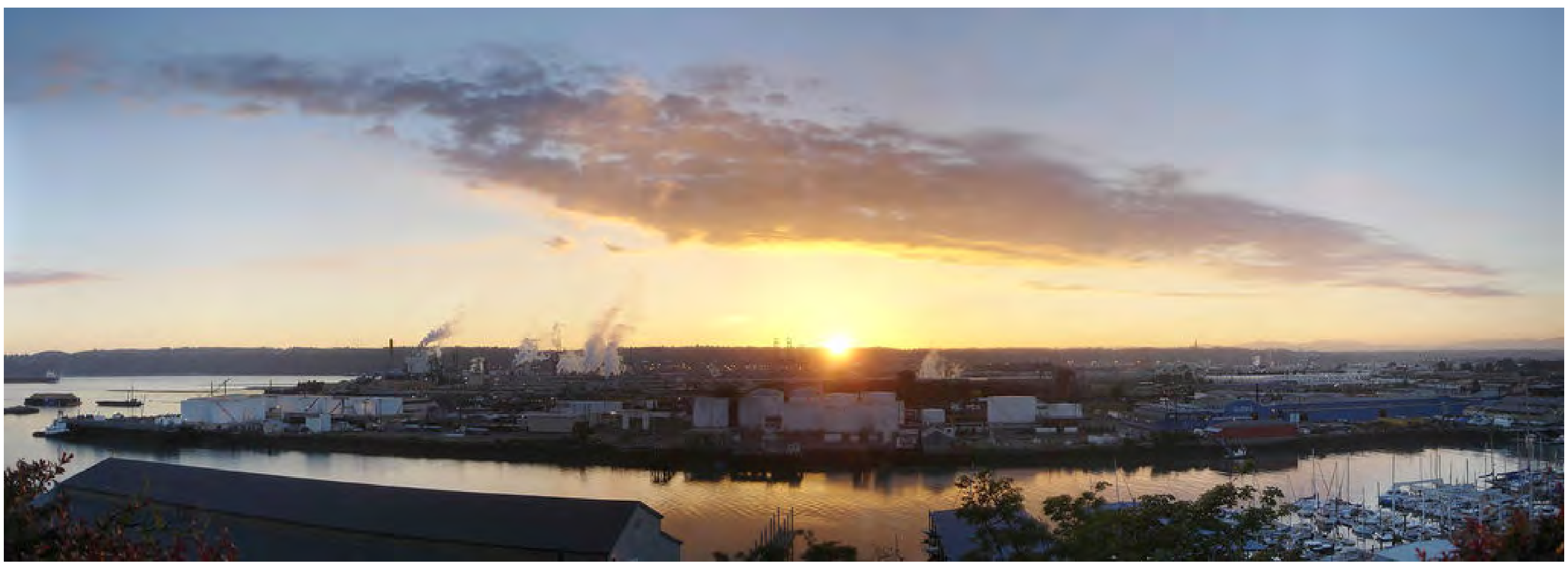


Photo Credit: mash187@flickr

Clean Sewers, Clean Thea Foss Waterway

LOCAL STORY

In response, Tacoma launched two new enhanced maintenance programs to prevent new and legacy contaminants from reaching the waterway.

- Storm Line Cleaning - completed in four entire drainages and part of a fifth between 2006 and 2011. This program was intended to remove legacy contaminants from storm pipe.
- Street sweeping - expanded to a more aggressive city-wide street sweeping program in 2007. This program was intended to remove more street contaminants preventing them from entering the storm system.

These two maintenance efforts, storm cleaning and street sweeping, were above and beyond Tacoma's NPDES permit requirements. This enhanced maintenance resulted in dramatic reductions in contaminant levels:

- PAH1 [1] concentrations showed 59-92% reductions in four drainages tested.
- DEHP [2] concentrations showed 26-68% reductions in three of the four drainages tested.
- TSS [3] concentrations showed 17- 44% reductions in three of the four drainages tested.
- Lead and zinc concentrations showed 11- 36% reductions in three drainages.

These programs were so successful that they are now part of Tacoma's city-wide operating procedures. The work is not over. The City of Tacoma's team of innovative stormwater professionals will continue to use every tool at its disposal–science, investigation, education, enforcement and even intuition – to do its part to protect the investment in the Thea Foss Waterway. Their mission is to create an asset for future generations by making sure stormwater discharges do not harm the health of the water and sediments in the Foss.

[1] PAH = Polycyclic aromatic hydrocarbons, PCB = polychlorinated biphenyl

[2] DEHP = Di-(2-Ethylhexyl) phthalate

[3] TSS = Total suspended solids

Toxics in Fish

Toxic pollutants in our bays, rivers, and streams can show up in the fish that live there, causing them to become diseased and posing a health threat to us when we eat the fish. Pollutants in the Puget Sound ecosystem include several important classes of chemicals including, PCBs, PBDEs, PAHs, and Endocrine Disrupting Compounds.

Concern over these chemicals in Puget Sound is high because they are toxic, they last for a long time in the ecosystem, and their levels increase in predators as the chemicals move up the food chain, a process called biomagnification. Measuring these pollutants in fish tissues tells us whether present-day levels are harmful to the fish or the predators that consume them and whether they are safe for us to eat.

Scientists have been tracking contaminant levels in Puget Sound fish since 1989 and have established threshold limits for these chemicals in fish tissues. These thresholds give us a guideline for the level of toxic chemicals that fish can tolerate, before they become diseased or show other harmful effects.

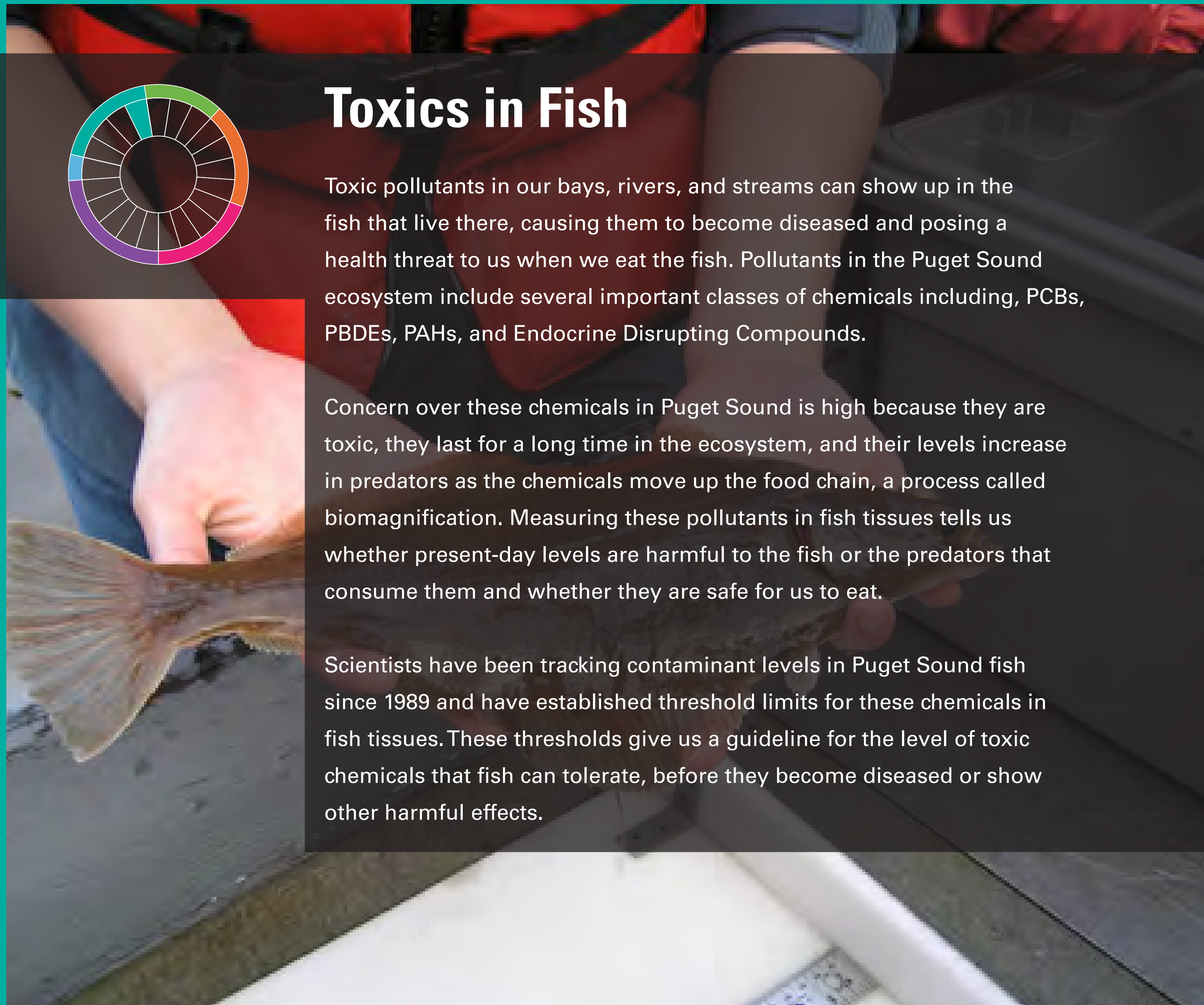


Photo Credit: Walter Rung

Toxics in Fish

INDICATOR:

1)Levels of four types of toxic contaminants in several species of fish
2)Contaminant-related disease in fish

Indicator lead: Jim West, Washington Department of Fish and Wildlife

TARGET:

Target 1) By 2020, contaminant levels in fish will be below health effects thresholds (i.e. levels considered harmful to fish health, or harmful to the health of people who consume them)
Target 2) By 2020, contaminant-related disease or impairments in fish are reduced to background levels

Progress Ttowards 2020 Targets

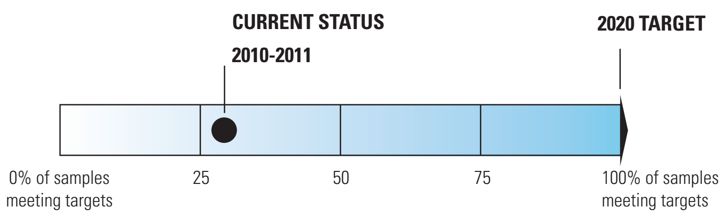
Of the four classes of toxic chemicals being tracked and reported on, one (polybrominated diphenyl ethers) show signs of progress, two (polychlorinated biphenyls and polycyclic aromatic hydrocarbons) show no change, and for one of the four (endocrine disrupting chemicals) there is not enough information to determine if progress is being made. The full 2020 target language for toxics in fish that was adopted by the Leadership Council is complex, relating four different classes of chemical contaminants to three different types of fish (herring, English sole, and salmon/steelhead), with four different concentration thresholds that range from no adverse effects to

Contaminant Type 1

Polychlorinated Biphenyls (PCBs)

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	NO



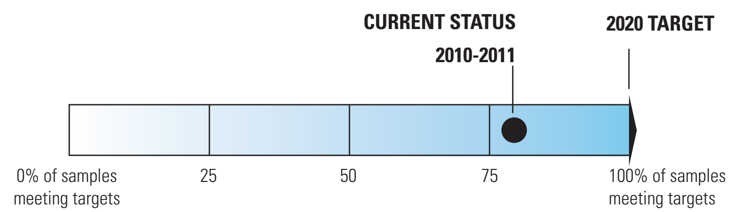
PCBs exceeded health effects thresholds or have been identified as a risk to seafood consumers in recent years for (1) urban English sole, (2) adult Chinook salmon returning to Puget Sound rivers, (3) juvenile Chinook salmon in Puget Sound or its river mouths, and (4) Pacific herring in Southern and Central Puget Sound. There has been no significant decline in PCBs in these species for the period monitored. However, adult coho salmon returning to Puget Sound rivers were below thresholds.

Contaminant Type 2

Flame Retardants (polybrominated diphenyls, or PBDEs)

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	YES



Evaluation of PBDEs is challenging because health effects thresholds are not yet available for some species. However, it appears that in most species levels are at or below obvious, immediate concern for most areas. In addition, PBDE levels appear to be declining in Pacific herring from Central and Southern Puget Sound.

no toxics-related reproductive impairment.

Making progress towards 2020 targets requires identifying which chemicals are most problematic, and then controlling their sources or cleaning up pollutants that have accumulated in the environment.

The danger of some chemicals (such as PCBs) was identified, and source controls imposed, over thirty years ago. PCB levels in Puget Sound fish today are probably ten times lower than they were in the 1970s, but they have not changed appreciably in the past 20 years. Current PCB levels are high enough to trigger Department of Health consumption advisories for Chinook salmon and other species, and are probably still high enough to harm fish health. Further reduction of PCBs in the ecosystem will likely require a combination of activities, including cleaning up contaminated sediments, identifying and halting new sources of PCBs into the system, and waiting for existing PCBs in the system to degrade or become unavailable.

Some progress towards 2020 targets for PBDEs has been made. The danger of flame retardants (polybrominated diphenyl ethers, or PBDEs) was recognized relatively recently, and source controls have been imposed. These include a legislated ban on the use of certain PBDE compounds and voluntary reduction in production of other compounds by industry. Although it is unclear whether these actions were responsible, PBDEs have been declining in one monitored species, Pacific herring, from Central and Southern Puget Sound, to levels that are likely below cause for concern.

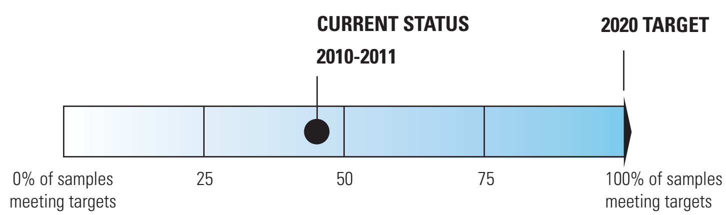
Progress related to hydrocarbons (polycyclic aromatic hydrocarbons, or PAHs) has been mixed. This is probably related to the huge range of sources for these compounds (they come from petroleum, and from burning fossil fuels), and the difficulty in controlling such pervasive sources. Some

Contaminant Type 3

Hydrocarbons (products of petroleum or combustion; polycyclic aromatic hydrocarbons, or PAHs)

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	NO



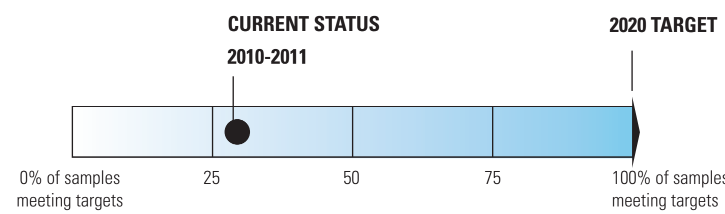
PAHs are tracked in fish by measuring byproducts (metabolites) of the compounds in their body fluids (in Pacific herring), or by measuring liver disease caused by PAH exposure (in English sole). PAHs levels in herring, a water-column species, from Central and Southern Puget Sound are similar to those of some urban English sole, a bottom-dwelling species. PAH levels in both species from these areas are cause for some concern. However PAH-related liver disease has declined to near background levels in one urban area (Elliott Bay).

Contaminant Type 4

Endocrine Disrupting Compounds (typically from pharmaceuticals, personal care products, but also from a wide range of other chemicals)

PROGRESS:

IS THE TARGET MET?	NO	IS THERE PROGRESS?	UNKNOWN



Endocrine disrupting compounds (EDCs) are chemicals that alter the normal hormonal system of fish, often resulting in problems related to growth or reproduction. EDCs have been evaluated in two species, English sole (adults) and Chinook salmon (juveniles). EDC-related feminization of male English sole was observed at five of six sampled locations, and in juvenile Chinook salmon from three of four sampled locations

Toxics in Fish

effects of PAHs in the ecosystem may be significant but are currently not monitored. Of the effects represented by this indicator, we have seen a dramatic decline in PAH-related liver disease from prevalence rates of over 30% to less than 10% in English sole from Elliott Bay, one of Puget Sound's most highly contaminated bays. The reason for this recovery is unclear, but could be related to sediment cleanup, removal of creosote-treated pilings, or control of new inputs to the bay.

Not enough monitoring has been conducted yet to fully evaluate progress towards the target of reducing Endocrine Disrupting Compounds (EDCs). These chemicals originate from a huge range of sources including pharmaceuticals, personal care products, plastics, other industrial, agricultural or household products, and some of the chemicals described above. EDC effects were observed in fish, primarily as a trend towards feminization of males, in most places where English sole and juvenile salmon were sampled. Only one status survey has been conducted for these species so far. Unlike the pollutants above, EDC effects have been observed in fish from waters surrounded by rural areas. Many of these chemicals can be introduced to aquatic systems via wastewater.

What are These Indicators?

Indicators

Each of the Toxics in Fish indicator metrics begins with a measure of the degree to which fish are exposed to toxic contaminants. In most cases this means measuring the chemicals in fish tissues, in the form of "tissue residues". In some cases fish systems can break down or metabolize the chemicals, in which case the pollutants don't accumulate in their bodies. In these cases chemists measure "metabolites" of the chemicals, usually in the bile or blood of the fish.

In order to understand the potential harm these chemicals may cause, these metrics also incorporate an understanding of the "health effects threshold" of each chemical for each species. This is the level of contamination an individual can tolerate before it experiences some health effect. The combination of knowing what contaminant levels the fish is exposed to with its tolerance for a chemical provides a guide for selecting recovery targets.

In some cases it is easier to measure contaminant-induced disease or other health impairment directly. Examples of these metrics in the Toxics in Fish Indicator are PAH-related liver disease and EDC-related reproductive impairment in English sole. In these cases it is possible to observe recovery of fish health directly, after exposure to the contaminant is removed from the fish's habitat.

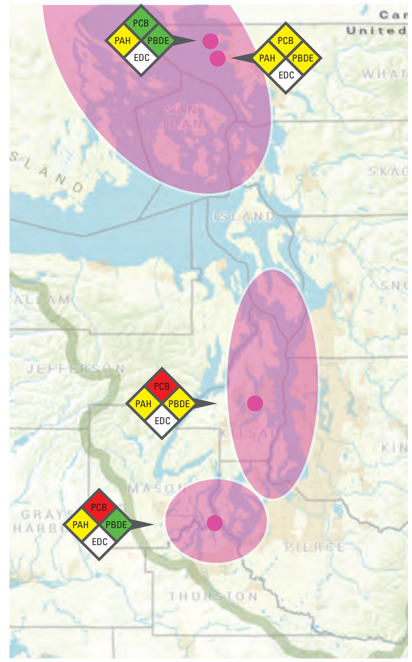
The Contaminant Monitoring Program

The Washington Department of Fish and Wildlife monitors toxic contaminants in fish and other organisms, as a member of the Puget Sound Ecosystem Monitoring Program (PSEMP). This program has tracked the indicator metrics described above for several species in the ecosystem, in addition to a number of chemicals not covered here. In addition, the PSEMP Toxics in Fish Unit has conducted a number of focus and diagnostic studies, along with partners including NOAA Fisheries, to develop new markers and investigate contaminants in the food web.

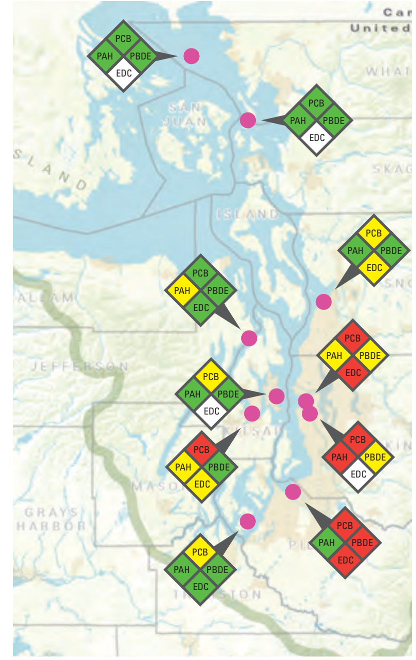
Interpretation of Data

The Indicator metrics provided in this summary simplify a highly complex relationship between exposure of organisms to pollutants, and the effects such exposure might have on their health. Toxic contaminants in Puget Sound are found in fish throughout the ecosystem – not just in urban areas, and not just in bottom-dwelling fish. In addition, many contaminants accumulate in fish as they age. Some of these "bioaccumulative" contaminants also move up the food chain, increasing to high concentrations in apex predators. It is important to interpret data with reference to where the fish live, where they were sampled, their age, and their position in Puget Sound's food web.

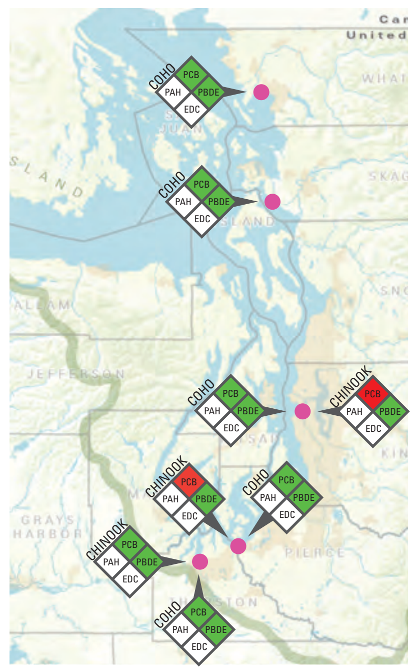
Pacific Herring



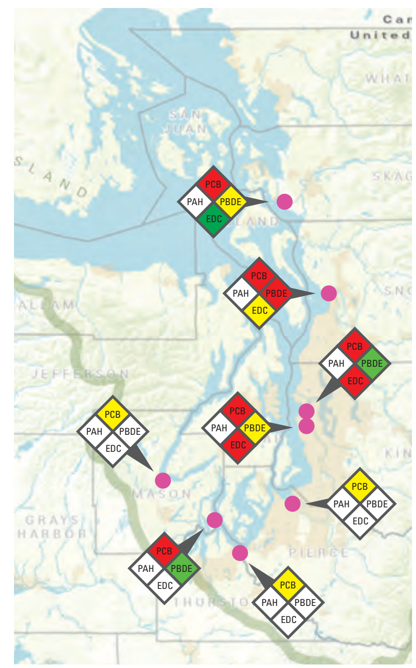
English Sole



Adult Chinook and Coho Salmon



Juvenile Chinook Salmon



Target not achieved
Intermediate
Target being met
No data